23.2 Electric Current

Lesson Objectives

- Define electric current.
- Explain how voltage is related to electric current.
- Identify sources of voltage
- Relate electric current to materials.
- State Ohm's law.

Lesson Vocabulary

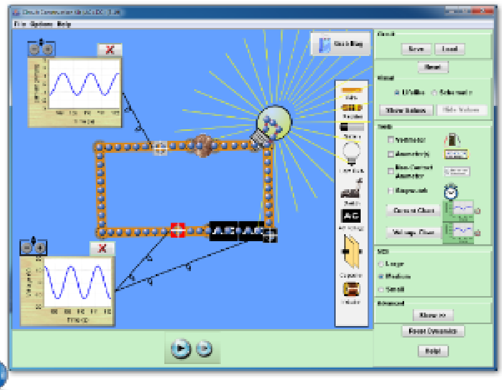
- alternating current (AC)
- direct current (DC)
- electric conductor
- electric current
- electric insulator
- Ohm's law
- resistance
- voltage

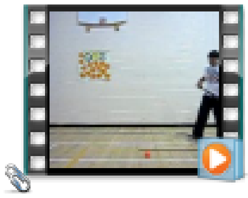
Introduction to Electric Current

Electric current is a continuous flow of electric charges. Current is measured as the amount of charge that flows past a given point in a certain amount of time. The SI unit for electric current is the ampere (A), or amp. Electric current may flow in just one direction, or it may keep reversing direction.

- When current flows in just one direction, it is called **direct current (DC)**. The current that flows through a battery-powered flashlight is direct current.
- When current keeps reversing direction, it is called **alternating current (AC)**. The current that runs through the wires in your home is alternating current.

Circuit Construction Kit (AC+DC)





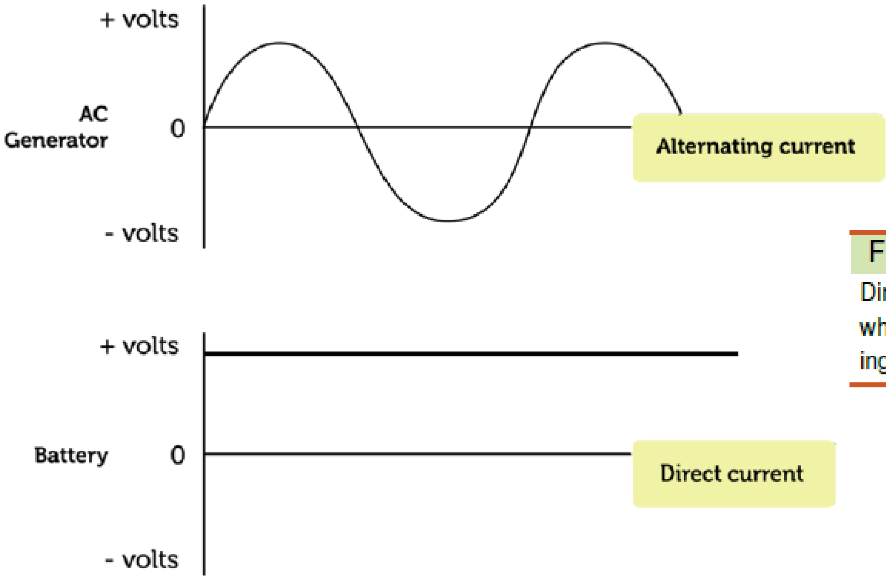


FIGURE 23.10

Direct current flows in one direction only, whereas alternating current keeps reversing direction.

Explaining Electric Current

Why do charges flow in an electric current? The answer has to do with electric potential energy. Potential energy is stored energy that an object has due to its position or shape. An electric charge has potential energy because of its position in an electric field. For example, when two negative charges are close together, they have potential energy because they repel each other and have the potential to push apart. If the charges move apart, their potential energy decreases. Electric charges always move spontaneously from a position where they have higher potential energy to a position where their potential energy is lower. This is similar to water falling over a dam from an area of higher to lower potential energy due to gravity.

In general, for an electric charge to move from one position to another, there must be a difference in electric potential energy between the two positions. The difference in electric potential energy is called potential difference, or **voltage**. Voltage is measured in an SI unit called the volt (V). For example, the terminals of the car battery in **Figure** 23.11 have a potential difference of 12 volts. This difference in voltage results in a spontaneous flow of charges, or electric current.

FIGURE 23.11

Most car batteries, like the one pictured here, are 12-volt batteries.

Sources of Voltage

Batteries like the one in **Figure** 23.11 are one of several possible sources of voltage needed to produce electric current. Sources of voltage include generators, chemical cells, and solar cells.

- Generators change the kinetic energy of a spinning turbine to electrical energy in a process called electromagnetic induction. You can read about generators and how they work in the chapter "Electromagnetism."
- Chemical and solar cells are devices that change chemical or light energy to electrical energy. You can read about both types of cells and how they work below.

Chemical Cells

Chemical cells are found in batteries. They produce voltage by means of chemical reactions. A chemical cell has two electrodes, which are strips made of different materials, such as zinc and carbon (see **Figure** 23.12). The electrodes are suspended in an electrolyte. An electrolyte is a substance containing free ions that can carry electric current. The electrolyte may be either a paste, in which case the cell is called a dry cell, or a liquid, in which case the cell is called a wet cell. Flashlight batteries contain dry cells. Car batteries contain wet cells. Animations at the URL below show how batteries work.

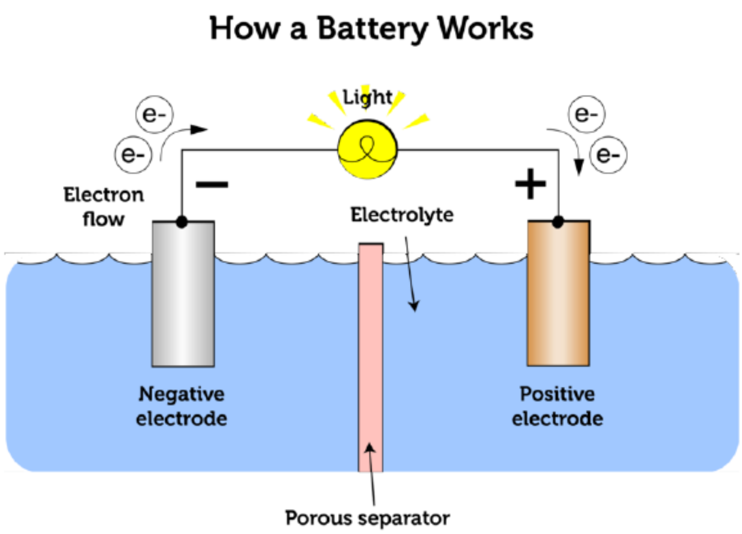


FIGURE 23.12
The simplest type of battery contains a single cell. The electrodes extend out of the battery for the attachment of wires that carry the current.

Both dry and wet cells work the same basic way. The electrodes react chemically with the electrolyte, causing one electrode to give up electrons and the other electrode to accept electrons. In the case of zinc and carbon electrodes, the zinc electrode attracts electrons and becomes negatively charged, while the carbon electrode gives up electrons and becomes positively charged. Electrons flow through the electrolyte from the negative to positive electrode. If wires are used to connect the two electrodes at their terminal ends, electric current will flow through the wires and can be used to power a light bulb or other electric device.

Solar Cells

Solar cells convert the energy in sunlight to electrical energy. They contain a material such as silicon that absorbs light energy and gives off electrons. The electrons flow and create electric current. **Figure** 23.13 and the animation at the URL below show how a solar cell uses light energy to produce electric current and power a light bulb. Many calculators and other devices are also powered by solar cells.

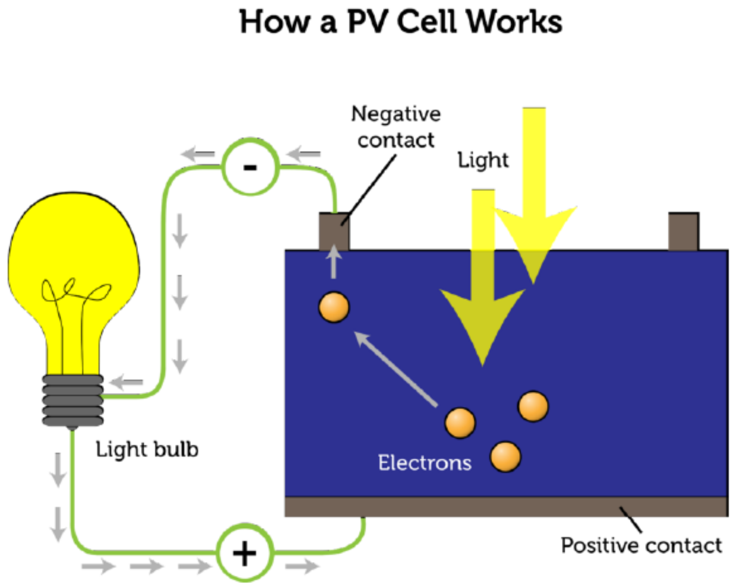


FIGURE 23.13
A solar cell is also called a photovoltaic (PV) cell because it uses light ("photo-") to produce voltage ("-voltaic"). The contacts in a PV cell are like the terminals in a chemical cell. One contact is negative and the other contact is positive, creating a difference in electric potential, or voltage, which produces electric current.

Resistance

Resistance is opposition to the flow of electric charges that occurs when electric current travels through matter. The SI unit of resistance is the ohm (named for the scientist Georg Ohm, whom you can read about below). Resistance is caused by electrons in a current bumping into electrons and ions in the matter through which the current is flowing.

Properties that Affect Resistance

For a given material, three properties of the material determine how resistant it is to electric current: length, width, and temperature. Consider an electric wire like one of the wires in **Figure** 23.14.

- A longer wire has more resistance. Current must travel farther, so there are more chances for it to collide with particles of wire.
- A wider wire has less resistance. A given amount of current has more room to flow through a wider wire.
- A cooler wire has less resistance than a warmer wire. Cooler particles have less kinetic energy, so they move more slowly. Current is less likely to collide with slowly moving particles. Materials called superconductors have virtually no resistance when they are cooled to extremely low temperatures. You can learn more about superconductors at this URL: http://www.dailymotion.com/video/x29bbd_superconductors_tech.

Ohm's Law

Voltage, or a difference in electric potential energy, is needed for electric current to flow. As you might have guessed, greater voltage results in more current. Resistance, on the other hand, opposes the flow of electric current, so greater resistance results in less current. These relationships between current, voltage, and resistance were first demonstrated by a German scientist named Georg Ohm in the early 1800s, so they are referred to as **Ohm's law**. Ohm's law can be represented by the following equation.

$$\text{Current (amps)} = \frac{\text{Voltage (volts)}}{\text{Resistance (ohms)}}$$

Electric Conductors and Insulators

Some materials resist the flow of electric current more or less than other materials do.

- Materials that have low resistance to electric current are called **electric conductors**. Many metals—including copper, aluminum, and steel—are good conductors of electricity. Water that has even a tiny amount of impurities in it is an electric conductor as well.
- Materials that have high resistance to electric current are called **electric insulators**. Wood, rubber, and plastic are examples of electric insulators. Dry air is also an electric insulator.

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Recall

1. What is electric current?
2. What is the difference between direct and alternating current?
3. Define voltage.
4. List three sources of voltage.
5. Identify three properties that affect the resistance of a given material.